Supplementary information file

Multimodal Luminescence in $Ca_2Ga_2GeO_7:Er^{3+},Yb^{3+}$ Phosphors for Optical Thermometry and Anti-Counterfeiting Applications

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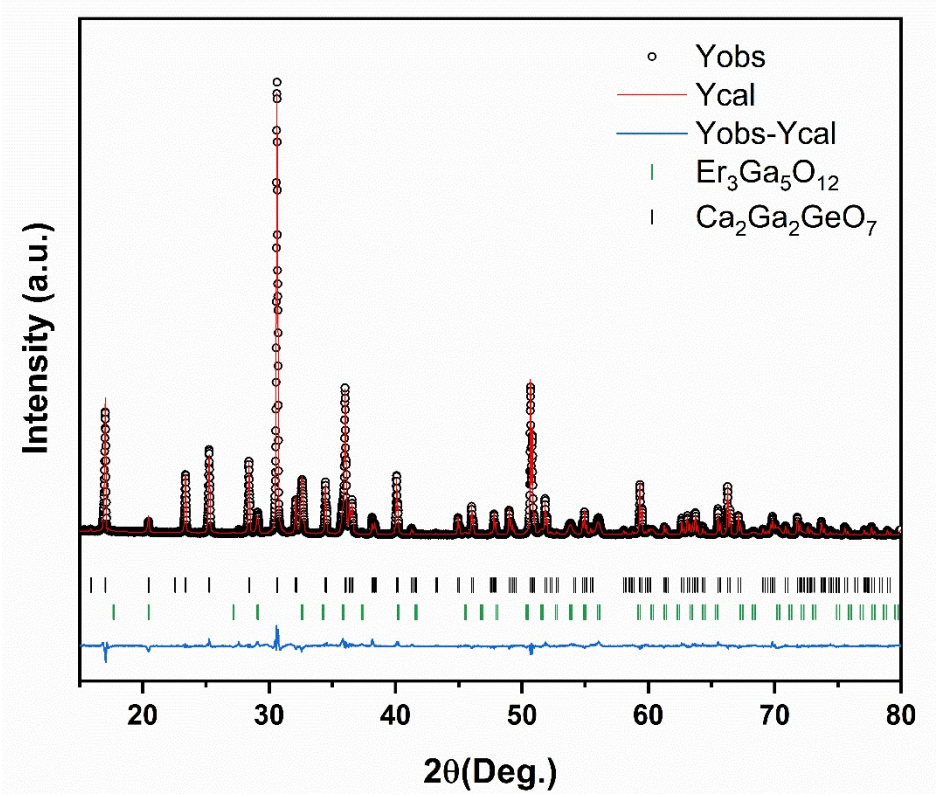

Figure S1: Rietveld plot for CGGO-5Er, 5Yb and fitting parameters of χ^2 =1.52, Rp= 6.2% Rwp= 8.27%

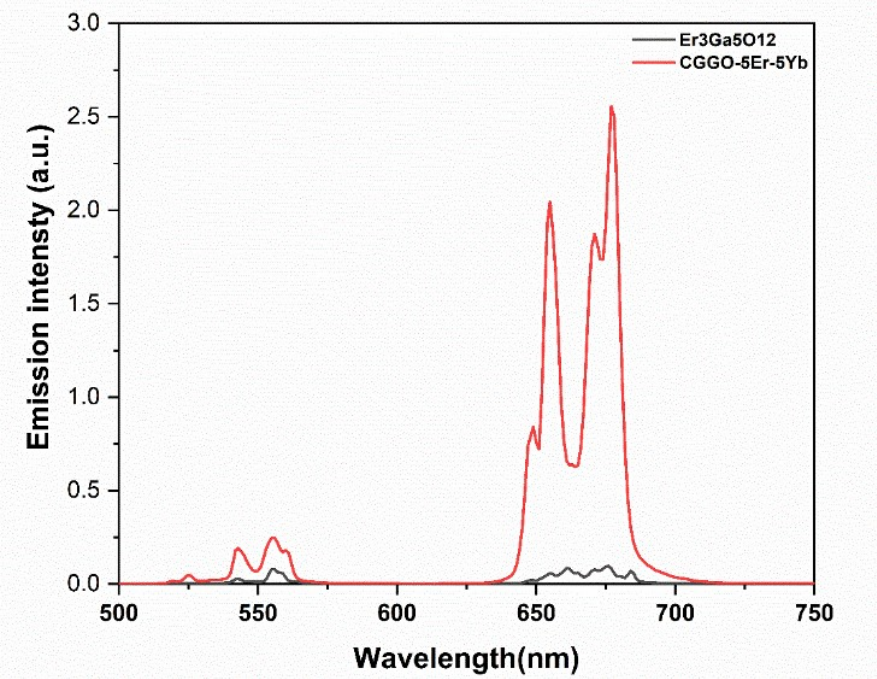

Figure S2: Emission spectra of CGGO-5Er,5Yb and $Er_3Ga_5O_{12}$.

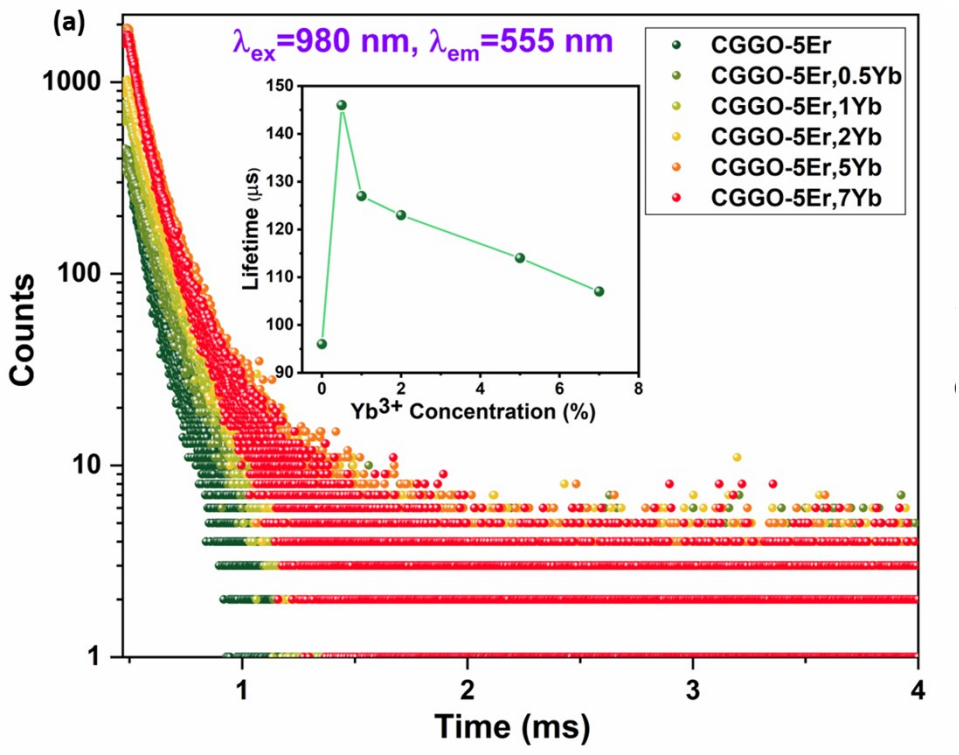

Figure S3: (a) Upconversion (UC) decay profile of CGGO-5Er, xYb phosphors monitored at an emission wavelength of 555 nm under 980 nm excitation.

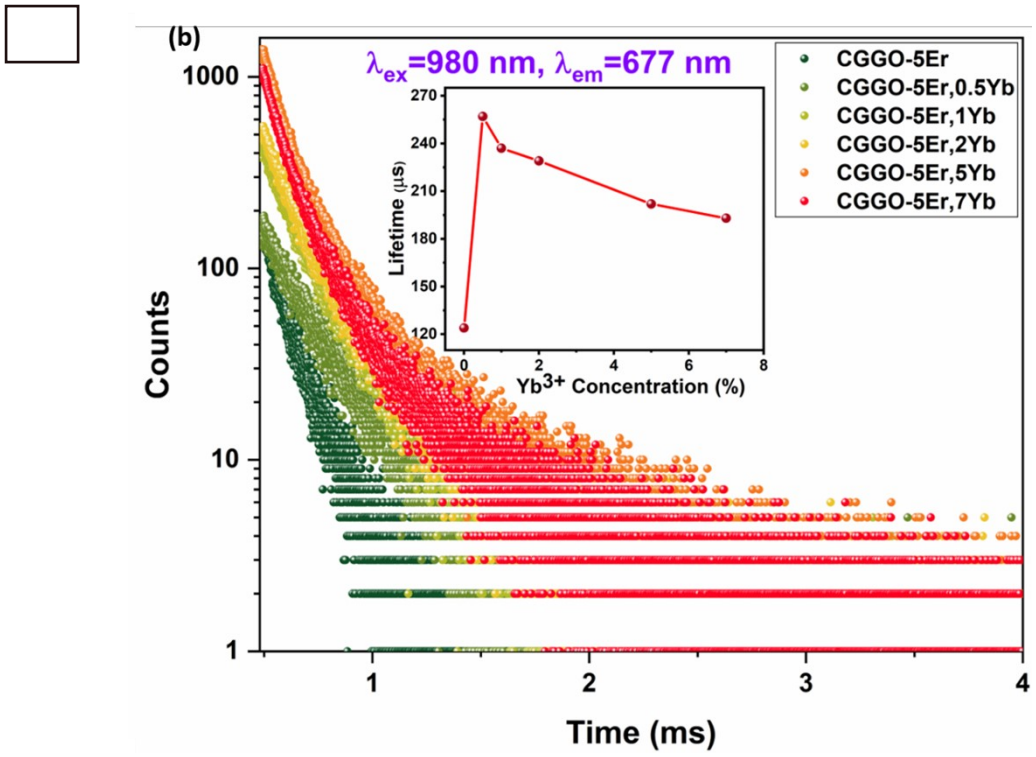

Figure S4: (a) Upconversion decay profile of CGGO-5Er, xYb phosphors monitored at an emission wavelength of 677 nm under 980 nm excitation.

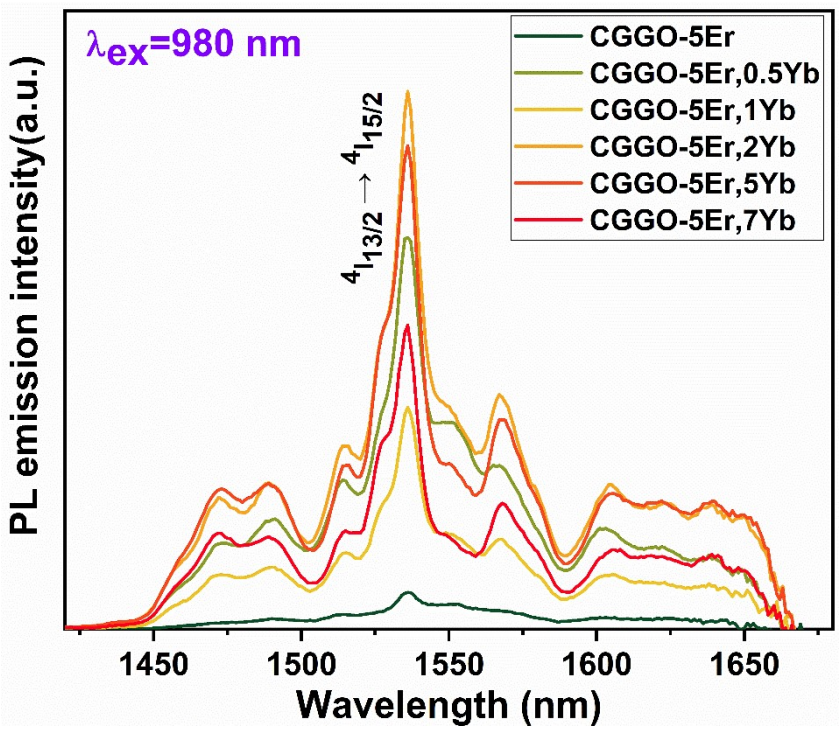

Figure S5: Emission spectra of CGGO-5Er, xYb phosphors in the NIR region under an excitation wavelength of 980 nm.

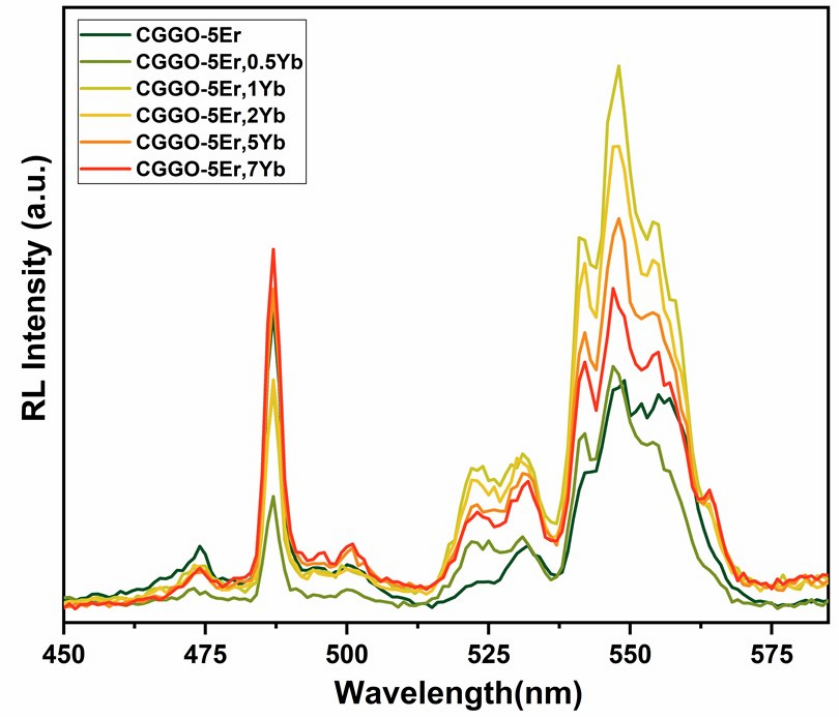

Figure S6: X-ray excited emission (radioluminescence) spectra of CGGO-5Er, xYb phosphors.

Table S1: Upconversion quantum yield of reported UC phosphors

UC Phosphor	λex (nm)	Upconversion quantum yield	Reference
La_2O_3:2%Yb^{3+}, 1%Er^{3+}	980	3.8%	[1]
$NaYF_4$: 2%Er^{3+},18%Yb^{3+} @$NaYF_4$	976	9%	[2]
$NaYF_4$:2%Er^{3+}, 20% Yb^{3+}	976	3%	[3]
YVO_4: Er^{3+}, Yb^{3+}	970	0.09%	[4]
Y_3NbO_7:Er^{3+}/Yb^{3+}	980	0.0020%	[5]
$SrGd_2O_4$:0.5%Er^{3+}, 5% Yb^{3+}	976	0.055%	[6]
β-$NaYF_4$: 3%Er^{3+},17%Yb^{3+}	980	10.5%	[7]
BaF_2:2%Er^{3+}, 3%Yb^{3+},	976	10%	[8]
La_2O_2S:1%Er^{3+} ,9%Yb^{3+}	977	5.8%	[9]
Er^{3+}/Yb^{3+} co-doped yttrium tantalates	980	0.016 %	[10]

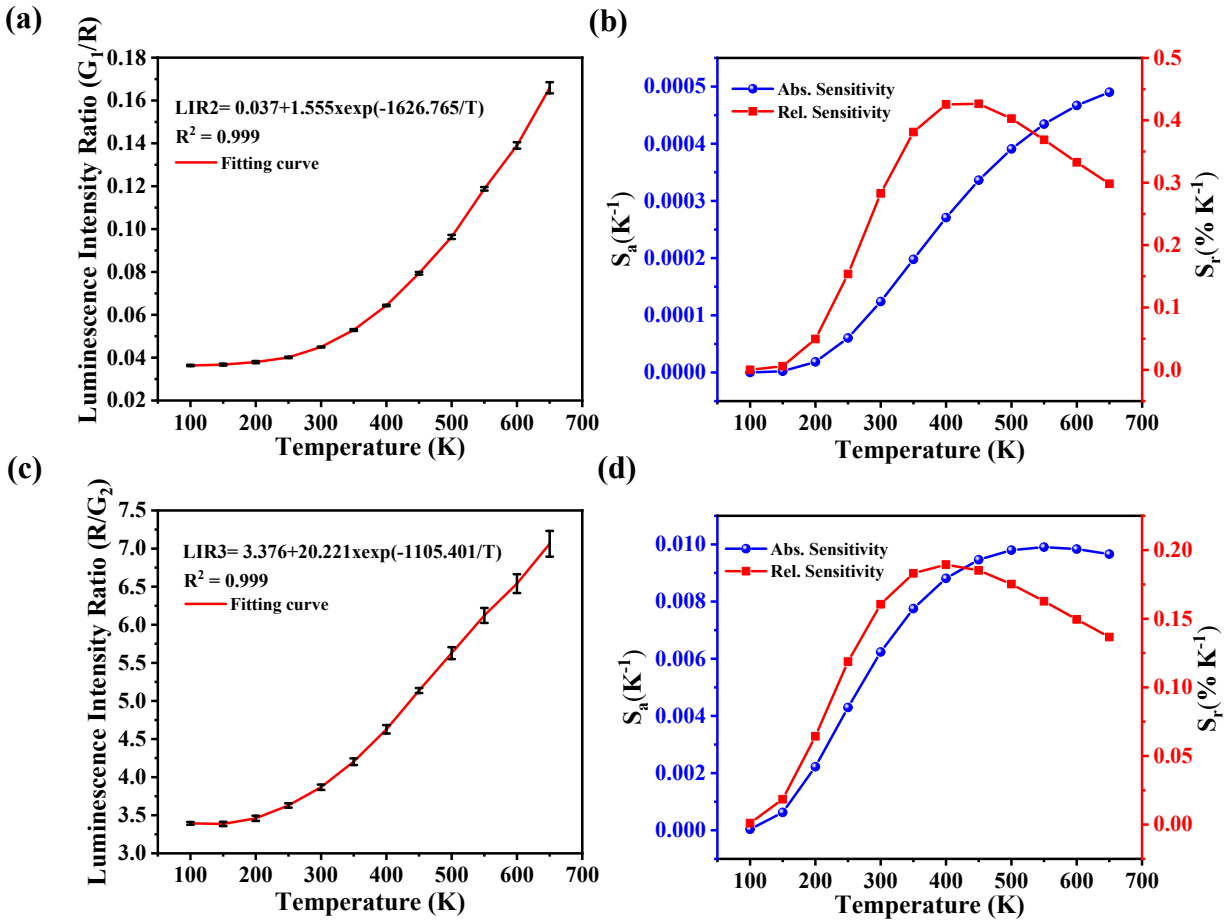

Figure S7: (a) Variation of the luminescence intensity ratio (G_1/R) with temperature with error bars, and (b) the corresponding absolute and relative sensitivities; (c) variation of the luminescence intensity ratio (R/G_2) with temperature with error bars, and (d) the corresponding absolute and relative sensitivities.

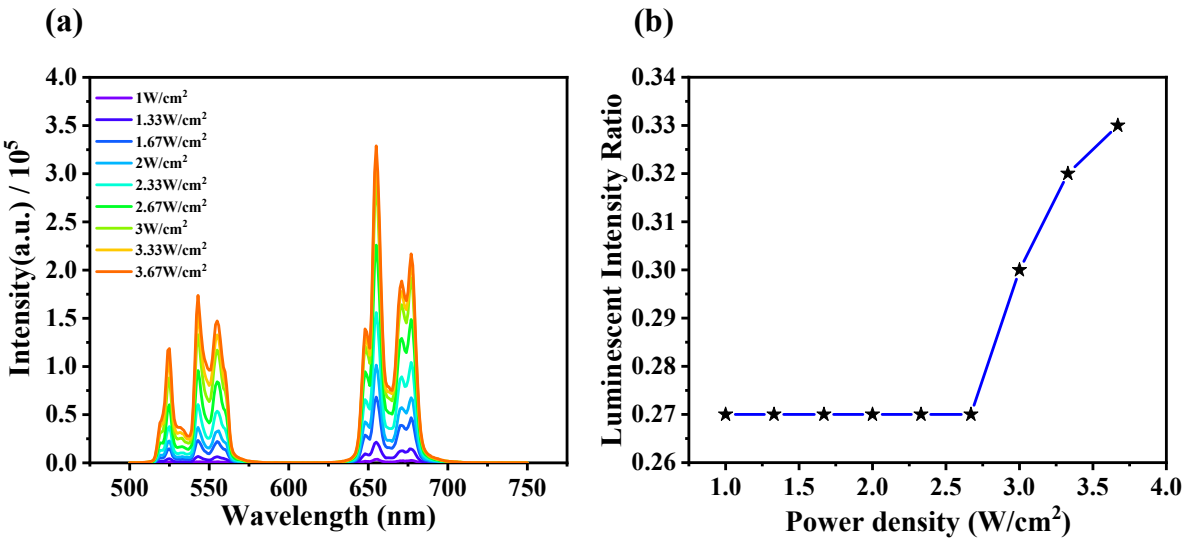

Figure S8: (a) Upconversion luminescence (UCL) spectra of CGGO:5% Er^{3+}, 5% Yb^{3+} acquired at different excitation power densities; (b) Variation of luminescence intensity ratio (LIR) with excitation power density at a fixed temperature of 350 K, used to evaluate excitation power-dependent thermal effects.

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